Fig.1.

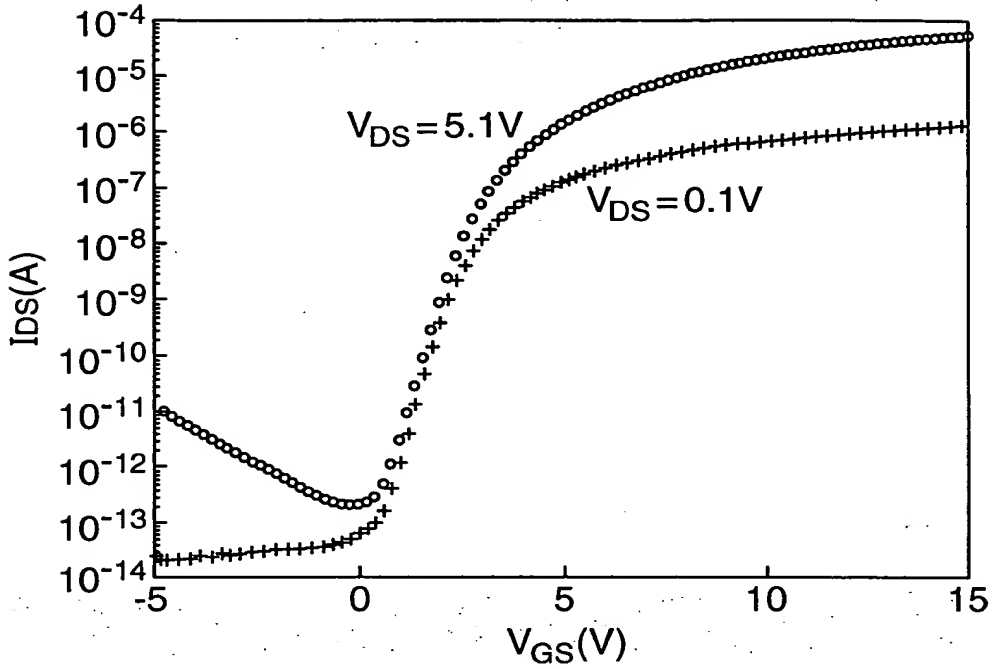
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
10^{-9}
10^{-10}
10^{-11}
10^{-12}
10^{-13}
10^{-14}
I_{DS}(A)
V_{DS}=5.1V
V_{DS}=0.1V
-5
0
5
10
15
V_{GS}(V)

Fig.5.

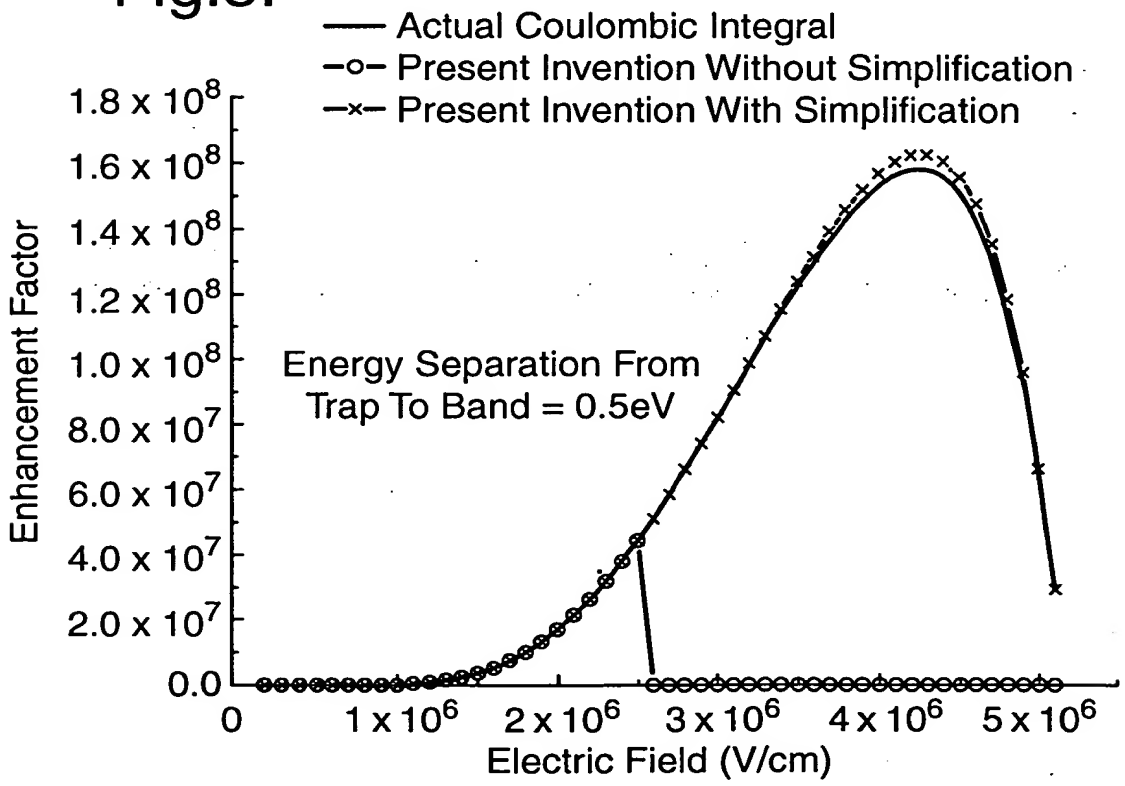
Actual Coulombic Integral
Present Invention Without Simplification
Present Invention With Simplification
1.8 x 10^8
1.6 x 10^8
1.4 x 10^8
1.2 x 10^8
1.0 x 10^8
8.0 x 10^7
6.0 x 10^7
4.0 x 10^7
2.0 x 10^7
0.0
Enhancement Factor
Energy Separation From
Trap To Band = 0.5eV
0
1 x 10^6
2 x 10^6
3 x 10^6
4 x 10^6
5 x 10^6
Electric Field (V/cm)

Fig.2.

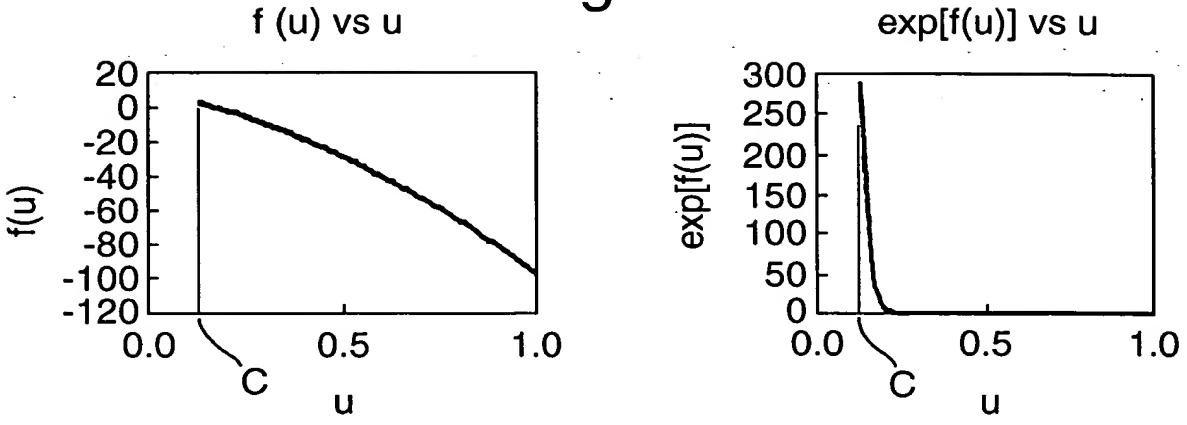

Fig.3.

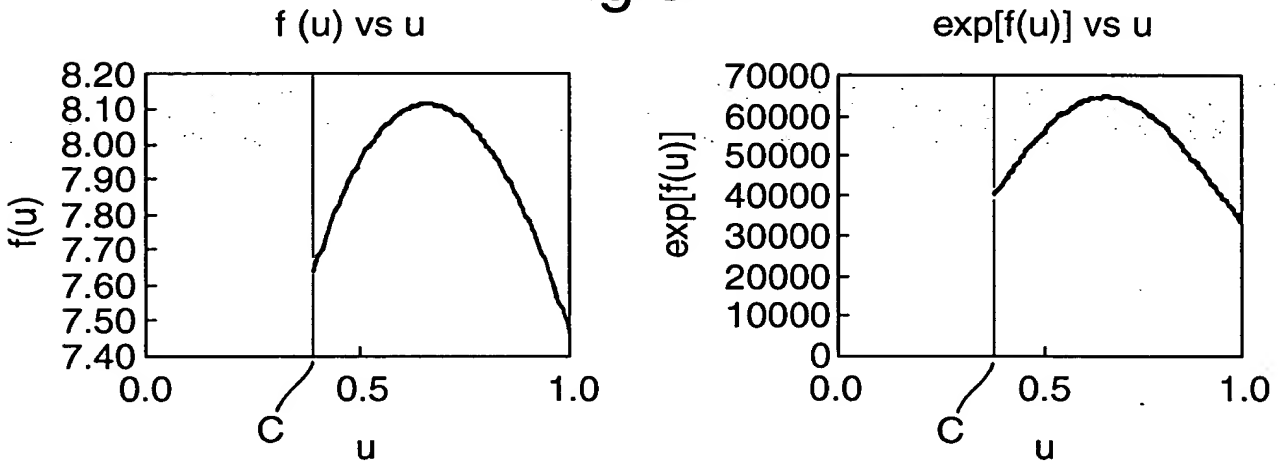

Fig.4.

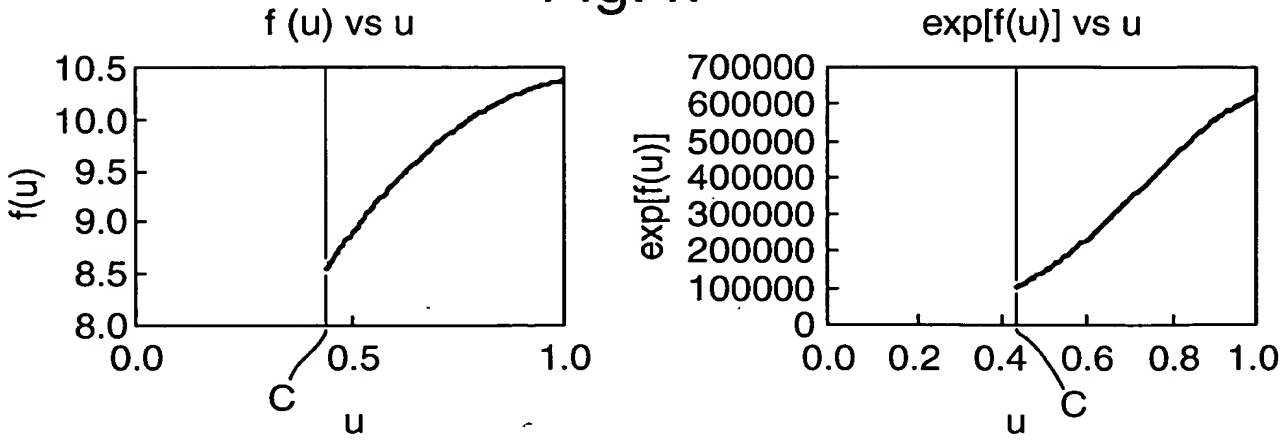

Fig.6.

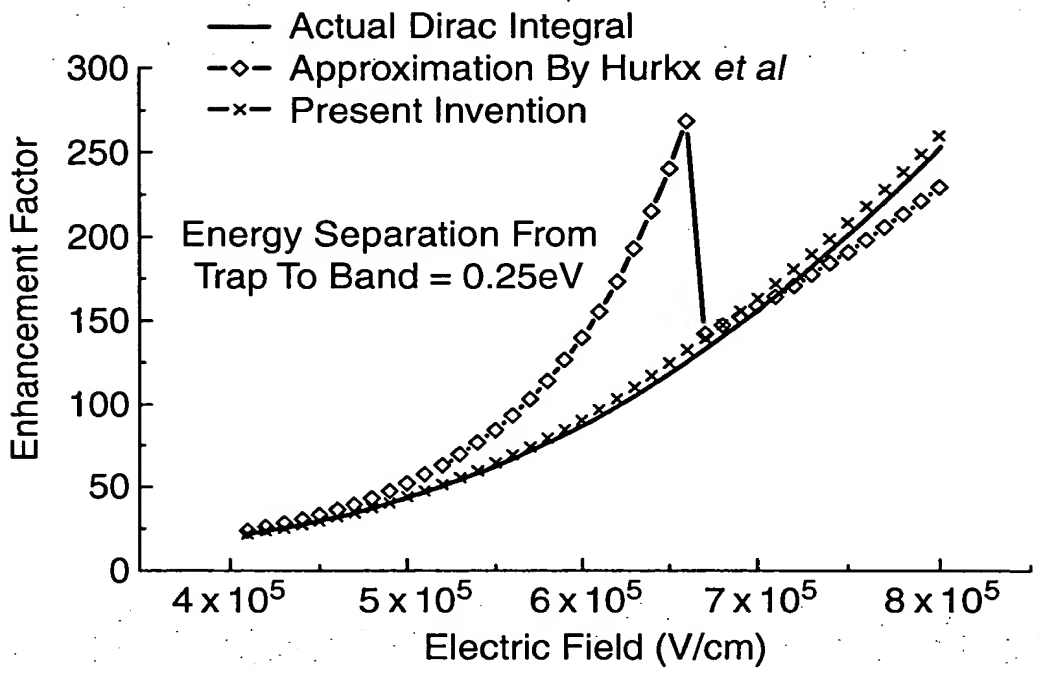
Actual Dirac Integral
Approximation By Hurkx *et al*
Present Invention
Energy Separation From
Trap To Band = 0.25eV
Enhancement Factor
300
250
200
150
100
50
0
4 x 10^5
5 x 10^5
6 x 10^5
7 x 10^5
8 x 10^5
Electric Field (V/cm)

Fig.7.

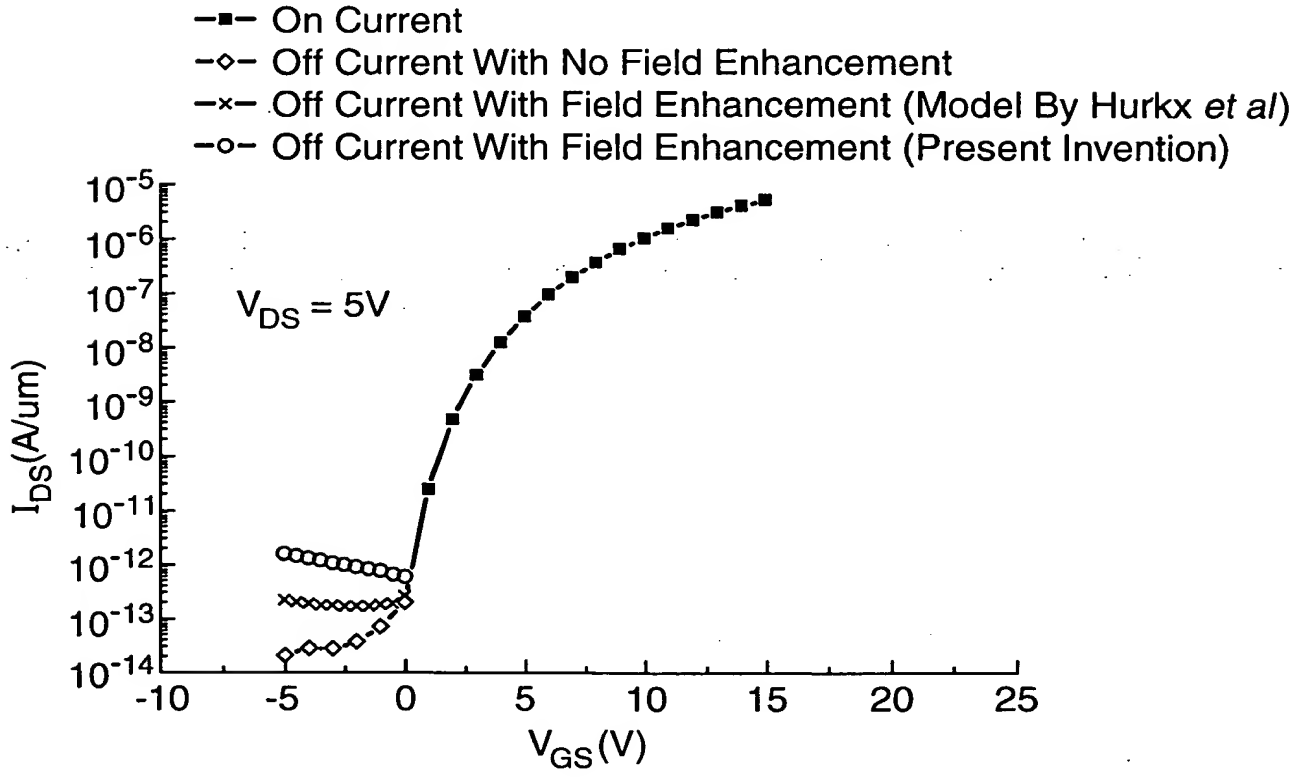
On Current
Off Current With No Field Enhancement
Off Current With Field Enhancement (Model By Hurkx *et al*)
Off Current With Field Enhancement (Present Invention)
V_{DS} = 5V
I_{DS}(A/um)
10^{-5}
10^{-6}
10^{-7}
10^{-8}
10^{-9}
10^{-10}
10^{-11}
10^{-12}
10^{-13}
10^{-14}
-10
-5
0
5
10
15
20
25
V_{GS}(V)

Fig.8.

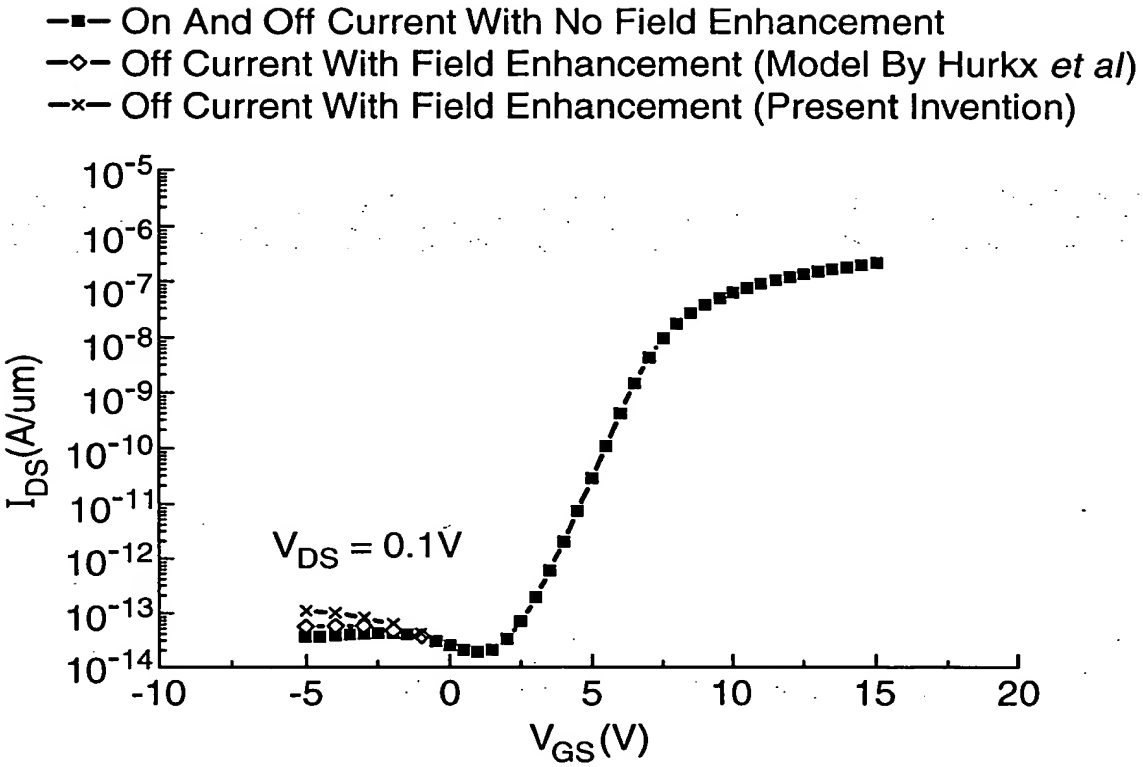
On And Off Current With No Field Enhancement
Off Current With Field Enhancement (Model By Hurkx et al)
Off Current With Field Enhancement (Present Invention)
10^{-5}
10^{-6}
10^{-7}
10^{-8}
10^{-9}
10^{-10}
10^{-11}
10^{-12}
10^{-13}
10^{-14}
I_{DS}(A/um)
V_{DS} = 0.1V
-10
-5
0
5
10
15
20
V_{GS}(V)

Fig.9.

$$\Gamma_n^{Coul} = \frac{\Delta E_n}{kT} \int_{\frac{\Delta E_{fp}}{\Delta E_n}}^{I} \exp\left\{ \frac{\Delta E_n}{kT} u - K_n u^{\frac{3}{2}} \left[1 - \left(\frac{\Delta E_{fp}}{u \Delta E_n} \right)^{\frac{5}{3}} \right] \right\} du \tag{1}$$

$$\Gamma_n^{Coul} = \frac{\Delta E_n}{kT} \int_{\frac{\Delta E_{fp}}{\Delta E_n}}^{I} \exp\left\{ \frac{\Delta E_n}{kT} u - K_n u^{\frac{3}{2}} + K_n \left(\frac{\Delta E_{fp}}{u \Delta E_n} \right)^{\frac{5}{3}} u^{-\frac{1}{6}} \right\} du. \tag{2}$$

$$A = \frac{\Delta E_n}{kT}, B = K_n, C = \frac{\Delta E_{fp}}{\Delta E_n}, D = BC^{\frac{5}{3}}. \tag{3}$$

$$\Gamma_n^{Coul} = A \int_c^I \exp\left\{ Au - Bu^{\frac{3}{2}} + Du^{-\frac{1}{6}} \right\} du. \tag{4}$$

$$\Gamma_n^{Coul} = A \int_c^I \exp\left[f(u) \right] du. \tag{5}$$

$$f(u) = Au - Bu^{\frac{3}{2}} + Du^{-\frac{1}{6}}. \tag{6}$$

$$f(u) \approx f(v) + f'(v)(u - v) + \frac{f''(v)}{2} (u - v)^2, \tag{7}$$

Fig.9(cont.a)

$$f(v) = Av - Bv^{\frac{3}{2}} + Dv^{-\frac{1}{6}}. \tag{8}$$

$$f'(v) = A - \frac{3}{2}Bv^{\frac{1}{2}} - \frac{1}{6}Dv^{-\frac{7}{6}}, \tag{9}$$

$$f''(v) = -\frac{3}{4}Bv^{-\frac{1}{2}} + \frac{7}{36}Dv^{-\frac{13}{6}}. \tag{10}$$

$$f(u) \approx \frac{f''(v)}{2}u^2 + [f'(v) - vf''(v)]u + \left[v^2\frac{f''(v)}{2} - vf'(v) + f(v)\right]. \tag{11}$$

$$f(u) \approx f''(v)\,u + [f'(v) - vf''(v)] = 0,$$

$$u_{max} = \frac{f'(v) - vf''(v)}{f''(v)}.$$

$$f(u) \approx -(AIu^2 + AIIu + AIII) \tag{12}$$

$$AI = -\frac{f''(v)}{2}. \tag{13}$$

$$AII = -[f'(v) - vf''(v)] \tag{14}$$

$$AIII = -\left[v^2\frac{f''(v)}{2} - vf'(v) + f(v)\right]. \tag{15}$$

$$f(u) \approx -AI\left[\left(u + \frac{AII}{2AI}\right)^2 + \left(\frac{AIII}{AI} - \left(\frac{AII}{2AI}\right)^2\right)\right]. \tag{16}$$

$$\Gamma_n^{Coul} = A\int_c^I \exp[f(u)]\,du \tag{17}$$

Fig.9(cont.b)

$$\Gamma_n^{Coul} = A \exp - \left[AI \left(\frac{AIII}{AI} - \left(\frac{AII}{2AI} \right)^2 \right) \right] \int_c^I \exp - \left[\sqrt{AI} \left(u + \frac{AII}{2AI} \right) \right]^2 du. \quad (18)$$

$$t = \sqrt{AI} \left(u + \frac{AII}{2AI} \right), \quad (19)$$

$$u = C,\ t_l = \sqrt{AI} \left(C + \frac{AII}{2AI} \right), \quad (20)$$

$$u = I,\ t_u = \sqrt{AI} \left(1 + \frac{AII}{2AI} \right), \quad (21)$$

$$du = \frac{1}{\sqrt{AI}}\, dt. \quad (22)$$

$$\Gamma_n^{Coul} = \frac{A}{\sqrt{AI}} \exp - \left[AI \left(\frac{AIII}{AI} - \left(\frac{AII}{2AI} \right)^2 \right) \right] \int_{t_l}^{t_u} e^{-t^2}\, dt. \quad (23)$$

$$\int_{t_l}^{t_u} e^{-t^2}\, dt = \frac{\sqrt{\pi}}{2} [erf(t_u) - erf(t_l)]. \quad (24)$$

$$erf(x) = 1 - (a_1 t + a_2 t^2 + a_3 t^3 + a_4 t^4 + a_5 t^5) e^{-x^2},$$

$$t = \frac{1}{1 + px},$$

$a_1 = 0.254829592;$
$a_2 = -0.284496736;$
$a_3 = 1.421413741;$
$a_4 = -1.453152027;$
$a_5 = 1.061405429;$
$p = 0.3275911;$ (25)

Fig.9(cont.c)

$$\Gamma_n^{Coul} = \frac{A}{2}\sqrt{\frac{\pi}{AI}}\left(\frac{a_1}{(1+pt_l)}+\frac{a_2}{(1+pt_l)^2}+\frac{a_3}{(1+pt_l)^3}+\frac{a_4}{(1+pt_l)^4}+\frac{a_5}{(1+pt_l)^5}\right)exp(-C^2AI - CAII - AIII)$$
$$- \frac{A}{2}\sqrt{\frac{\pi}{AI}}\left(\frac{a_1}{(1+pt_u)}+\frac{a_2}{(1+pt_u)^2}+\frac{a_3}{(1+pt_u)^3}+\frac{a_4}{(1+pt_u)^4}+\frac{a_5}{(1+pt_u)^5}\right)exp(-AI - AII - AIII) \quad (26)$$

$$AI = -\frac{f''(v)}{2},\ AII = -[f'(v) - vf''(v)],\ AIII = -\left[v^2\frac{f''(v)}{2} - vf'(v) + f(v)\right],$$

$$t_l = \sqrt{AI}\left(C+\frac{AII}{2AI}\right),\ t_u = \sqrt{AI}\left(1+\frac{AII}{2AI}\right),$$

$$f(v) = Av - Bv^{\frac{3}{2}} + Dv^{-\frac{1}{6}},$$

$$f'(v) = A - \frac{3}{2}Bv^{\frac{1}{2}} - \frac{1}{6}Dv^{-\frac{7}{6}},$$

$$f''(v) = -\frac{3}{4}Bv^{-\frac{1}{2}} + \frac{7}{36}Dv^{-\frac{13}{6}},$$

Fig.9(cont.d)

$$A = \frac{\Delta E_n}{kT},\ B = K_n, C = \frac{\Delta E_{fp}}{\Delta E_n},\ D = BC^{\frac{5}{3}}.$$

$v = C$(for $u_{max} < C$, case 1),

$v = u_{max}$ (for $C < u_{max} < I$, case 2),

$v = I$(for $u_{max} \geq 1$, case 3),

$$u_{max} = \frac{f'(v) - vf''(v)}{f''(v)} \text{ for } v = \frac{C+1}{2}.$$

$$\begin{aligned}\Gamma_n^{Coul} = {} & \frac{A}{2}\sqrt{\frac{\pi}{AI}}\left(\frac{a_1}{(1+pt_l)} + \frac{a_2}{(1+pt_l)^2} + \frac{a_3}{(1+pt_l)^3} + \frac{a_4}{(1+pt_l)^4} + \frac{a_5}{(1+pt_l)^5}\right) exp(-C^2AI - CAII - AIII) \\ & - \frac{A}{2}\sqrt{\frac{\pi}{AI}}\left(\frac{a_1}{(1+pt_u)} + \frac{a_2}{(1+pt_u)^2} + \frac{a_3}{(1+pt_u)^3} + \frac{a_4}{(1+pt_u)^4} + \frac{a_5}{(1+pt_u)^5}\right) exp(-AI - AII - AIII) \\ & \pm \frac{A}{2}\sqrt{\frac{\pi}{AI}}\ \exp\left(-AIII + \frac{AII^2}{4AI}\right)\end{aligned} \quad (27)$$